CHAPTER 3

COMBAT SYSTEMS ALIGNMENT (GUN/BATTERY)

LEARNING OBJECTIVES

Upon completing this chapter, you should be able to do the following:

1. Describe the purpose of battery alignment.
2. Identify the primary equipment used in battery alignment.
3. Identify the alignment considerations needed for an accurate battery alignment.

INTRODUCTION

Combat systems alignment (gun/battery alignment) is the process of adjusting all the elements of a weapons system (including all gun bores, missile launchers, fire-control directors, radar antennas, and optics) to common reference points, lines, and planes, and maintaining them in this relationship. Battery alignment is a critical factor in the fighting effectiveness of any combat ship. Without proper battery alignment, the data exchanges between elements of the weapons systems would be in error.

The battery alignment of a ship is accomplished by two distinct procedures—original alignment (drydock alignment) and alignment afloat. Original alignment is the initial alignment made in a fire-control and weapons system at the time of original construction and installation. Original alignment is also performed when a new or modified major weapons system is installed. A check of this alignment is made when the ship is in dry dock.

Alignment afloat refers to alignment operations performed while the ship is in the water. Alignment afloat requires standards of accuracy just as high as those of the original alignment, with the primary difference being that alignment afloat is performed by combat systems department personnel with equipment available on the ship.

As a Fire Controlman, you must be able to correctly apply battery alignments. For more information on this topic, refer to the alignment procedures for your class of ship.

BATTERY-ALIGNMENT CONCEPTS

Battery alignment is based on the concepts of parallel lines, parallel planes, and a geometric coordinate system. Parallel lines are those lines in the same plane that, when extended indefinitely, do not intersect. Parallel planes are those planes that do not intersect. A geometric coordinate system provides a method for determining the position of a point, a line, a curve, or a plane in a space of given dimensions, called a *reference frame.* Figure 3-1 shows typical examples of parallel lines and planes.

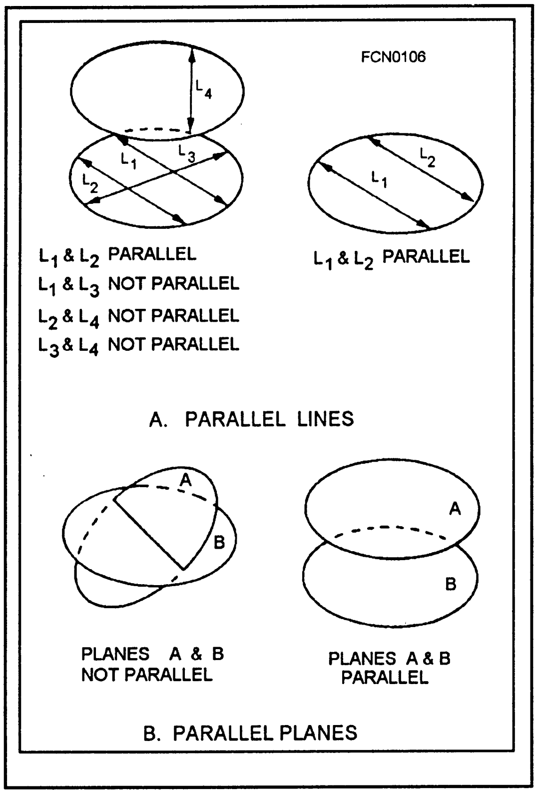

Figure 3-1.—Typical examples of parallel lines and planes.

Ultimately, the alignment of parallel lines, parallel planes, and coordinate systems is used to establish a pointing line for each piece of equipment in the ship's combat system. The line representing the direction in which apiece of equipment is pointing is the pointing line of that equipment. As previously indicated, the pointing line may be the bore axis of a gun, the line of sight of a director, or the propagation axis of a radar beam. Accurate alignment is not possible unless the pointing line is precisely determined.

FRAME OF REFERENCE

The reference point, the reference direction, and the reference plane form a geometric structure called the *reference plane.* In the complete reference frame, directions are specified by two angles (train and elevation), measured about the reference point. Figure 3-2 shows the measurement of an angle from a reference direction.

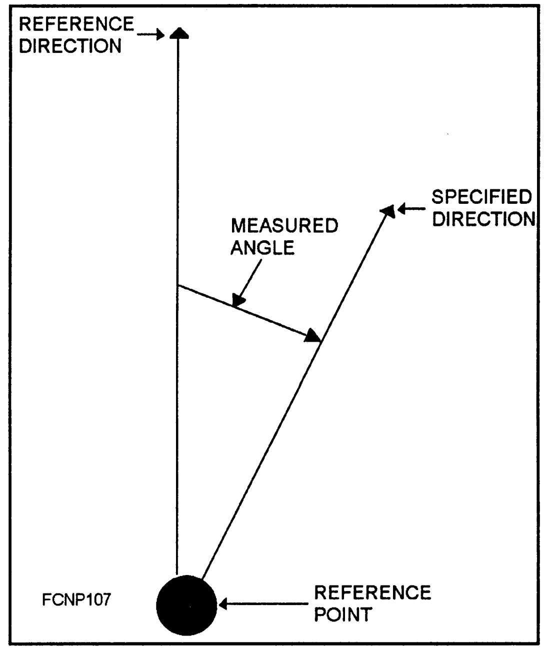

Figure 3-2.—Measurement of an angle from a reference direction.

A geometric measurement is based on a definite and complete set of geometric references. To permit clear and accurate definition of target position, a definite point on the ship (such as a director) is selected as the starting point for the measurement. As a reference point, a director center of rotation is selected arbitrarily because the director has interface with all the major equipment of a battery. Once the reference point is determined, it becomes apart of any future measurement made from it and must be clearly specified before subsequent measurements have any meaning.

Once the reference point is selected, a reference direction is established from which train angles are measured. Train angles are measured about the reference point, beginning at the reference direction. In naval combat systems, the ship's centerline, which points in the direction of the bow, is used as the reference direction.

Angles expressing direction cannot be described unless a means is available for specifying the plane in which the angle is to be measured. This plane is referred to as the *reference plane* and maybe any plane convenient for use. The horizontal plane is one of the most commonly used reference planes because of the ease of using a spirit level or similar device to determine the plane. In naval combat systems, the reference plane is parallel to the reference element (the director) roller path. Whichever plane is selected for reference, it must be clearly specified before subsequent measurements are of any significance. When the reference plane is used, a means must be established to denote the top of the plane to express the angle correctly. Train angles are measured clockwise from the reference direction on the top of the plane. Figure 3-3 shows a typical reference plane.

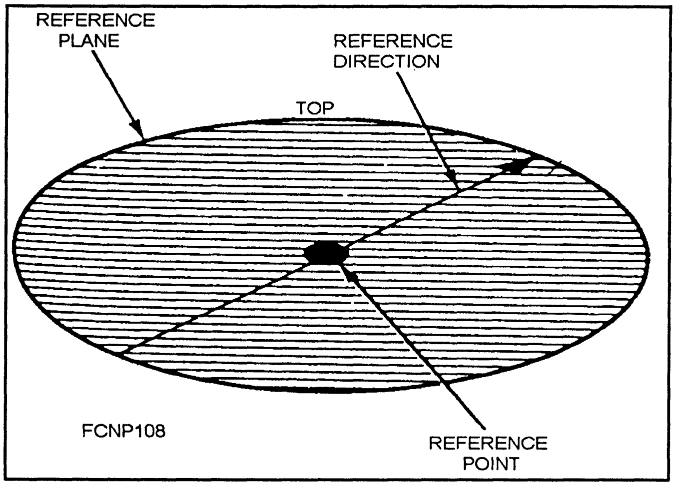

Figure 3-3.—Typical reference plane.

The elevation angle is in a plane perpendicular to the horizontal reference plane and is measured from the reference plane. The concept of a reference frame is important in the expression of a direction and the problems related to alignment. The reference point is a definite point aboard ship, and the reference plane and the reference direction have a definite orientation in respect to the reference point.

In fire control, it is often necessary to operate simultaneously with two or more reference frames. (For instance, these frames might be situated in different parts of a ship.) It maybe desirable to measure target data with several directors because of a need for flexibility in controlling different fire-control systems to obtain a wide range of view or if one director is out of commission. In such an event, you must be able to use the target data from either of the directors to get a fire-control solution. To interpret data measured in different frames, you must know how the frames are situated with respect to each other. Figure 3-4 is representation of a complete reference frame.

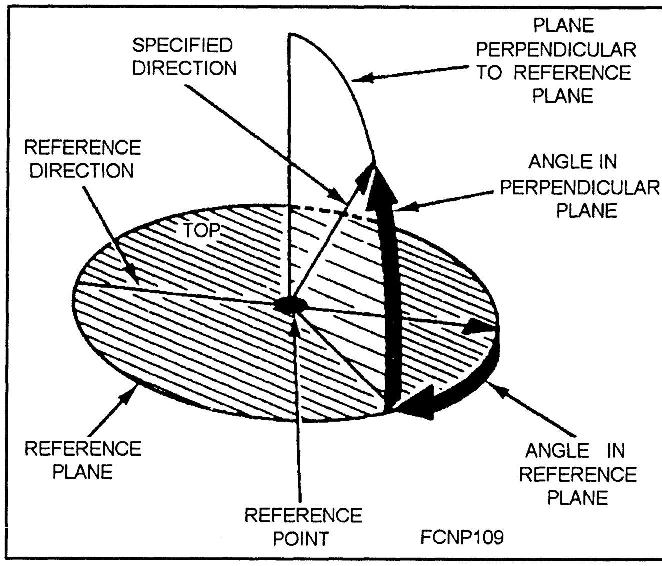

Figure 3-4.—Representation of a complete reference frame.

The difference or displacement between two frames may be of two kinds—linear and angular.

Linear Displacement

Linear displacement is the distance between two reference frames measured between their reference points. This displacement may be in the vertical direction, the horizontal direction, or both.

The corrections made necessary by the linear displacement between the reference points are called *parallax corrections* and are considered separately from corrections arising from the rotation between the frames. Parallax corrections can be separated into either dynamic parallax corrections or static parallax corrections.

DYNAMIC PARALLAX CORRECTIONS.— Position quantities computed for the reference frame are correct only for equipment located exactly at the reference point. Dynamic differences result because the motion of equipment not located at the reference point is different from the motion of equipment located at the reference point because of the rolling and pitching of the ship. These dynamic factors are usually negligible and are not normally corrected.

STATIC PARALLAX CORRECTIONS.— Static parallax is caused by the linear and angular displacements between the reference point and the equipment located elsewhere on the ship. Figure 3-5 shows two parallel reference frames (X and Y) displaced from each other by the distance (d). Frame X is the standard reference frame. The bearing of target (T), as determined from reference frame X, is 60°. If this is applied in a reference frame at Y, the line YT is determined. This line is parallel to XT, but it does not pass through the target because of the displacement between the reference frames. To cause the line from Y to pass through the target in this example, a parallax correction angle of 10° must be subtracted from the bearing value measured for frame X.

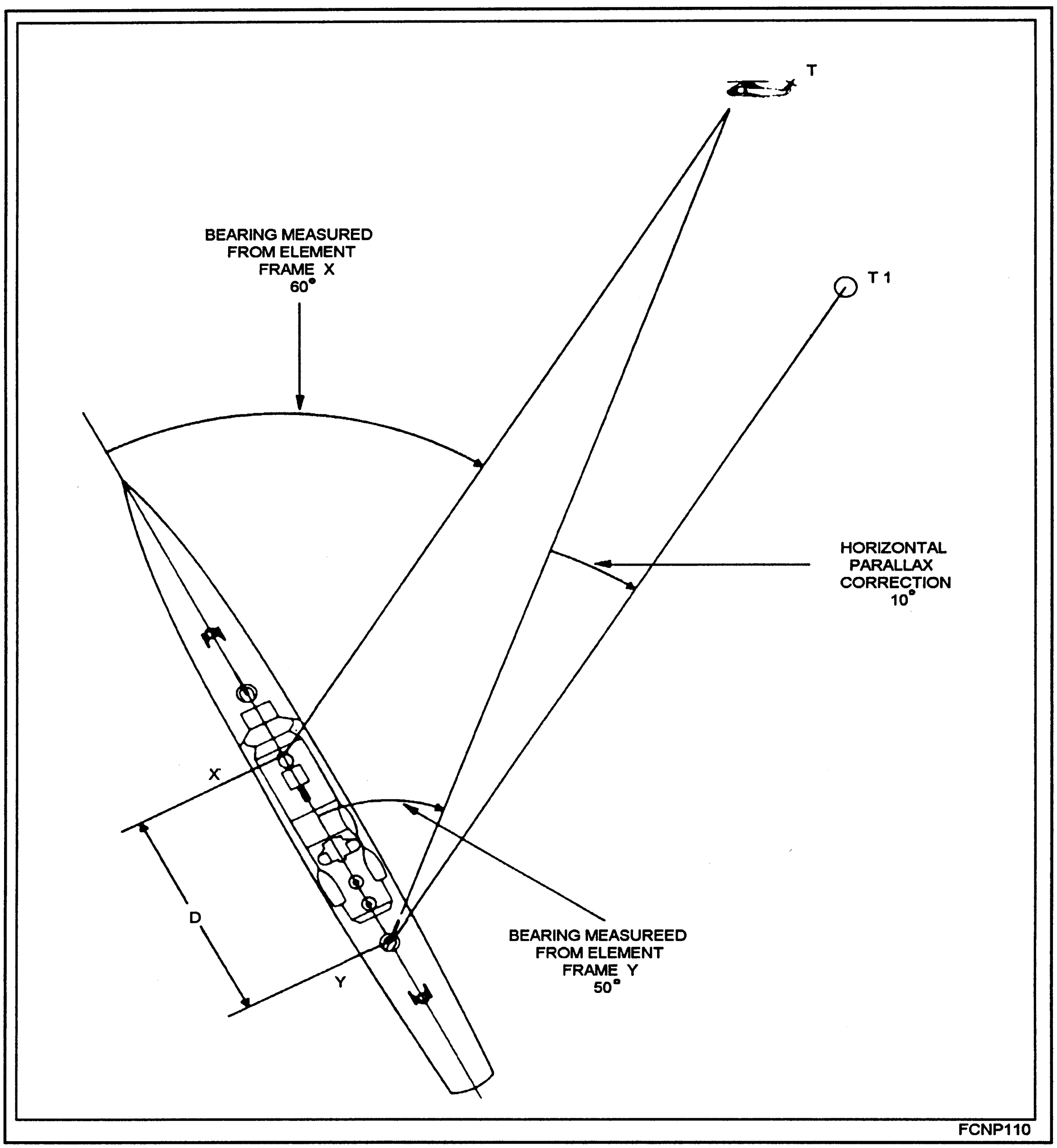

Figure 3-5.—Parallax resulting from linear displacement of two frames.

Elevation angles also are affected by displacements between reference frames. If elevation angles measured in one frame are to be used in another frame, they must first be corrected for parallax. The magnitudes of parallax corrections in train and elevation vary considerably with target bearing, elevation, and range, and the magnitude and orientation of the distance between the reference frames.

The basic point to remember is that whenever two reference frames are displaced from each other, data measured from one frame is, in general, not equal to data measured from the other frame. If the differences are significant, data measured in one frame must be corrected for parallax before it is applied in other frames.

Angular Displacement

Connections arising from reference directions or reference planes not being parallel are called *rotational corrections.* If the reference lines are both in a plane that is perpendicular to both reference planes, but the reference planes are not parallel, the bearing angles and the elevation angles are different.

When the angle between the reference planes is relatively small, the major difference is in the elevation angles; the difference in the bearing angles is usually small enough to be ignored.

Figure 3-6 shows rotational corrections between unparallel planes.

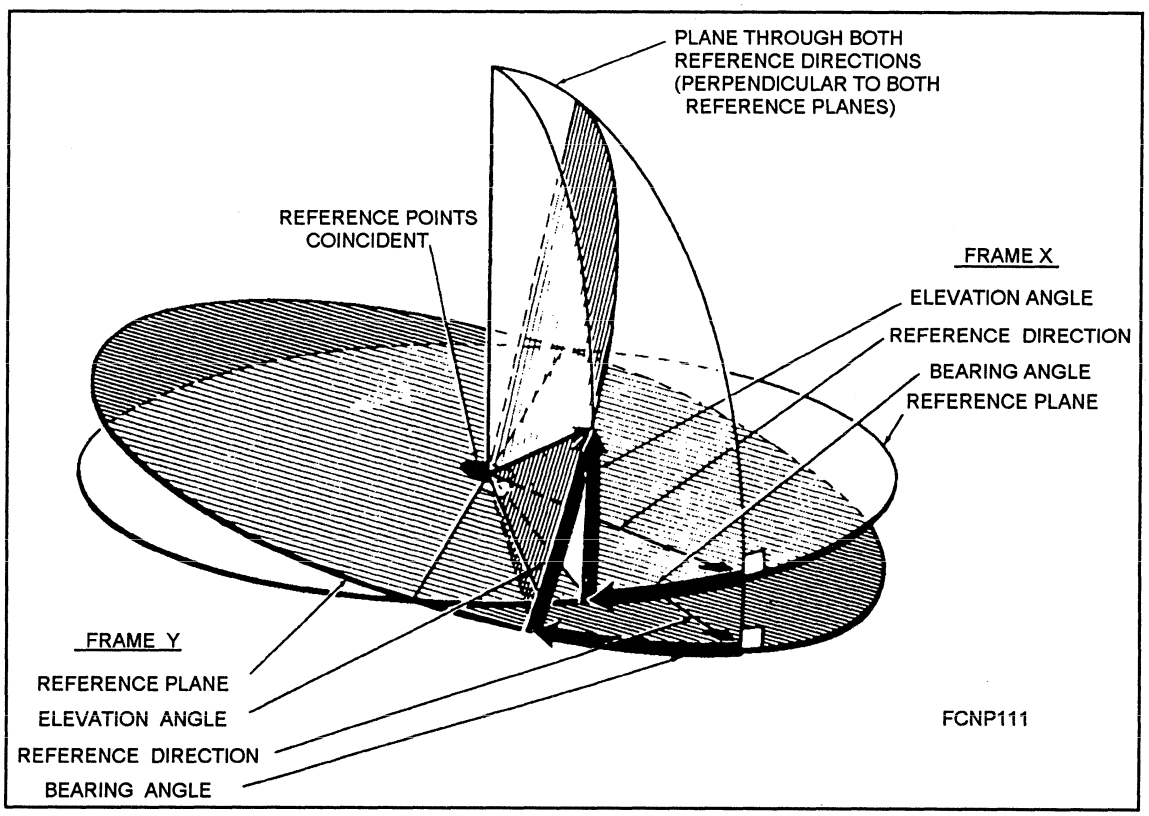

Figure 3-6.—Rotational corrections between unparallel planes.

ALIGNMENT EQUIPMENT

Alignment equipment is used by shipboard and shipyard personnel to align combat systems elements. Combat systems alignment checks and adjustments are usually accomplished with tools and test equipment normally found aboard ship. Because of required combat systems accuracy, special-purpose instruments are sometimes required for adjustments.

This section briefly describes the most commonly used alignment equipment, such as transits, theodelites, clinometers, levels, alignment sights, tram bars and blocks, benchmarks, and dials.

TRANSITS

A transit is an optical-surveying instrument that is used for measuring angles. Essentially, the transit provides an optical line of sight (LOS) that is perpendicular to, and supported on, a horizontal axis. The horizontal axis is perpendicular to a vertical axis about which it can rotate. Spirit levels are used to make the vertical axis coincide with the direction of gravity. Graduated circles with verniers are used to read the angles. A typical transit is shown in figure 3-7.

THEODOLITES

Theodolites are similar to transits, but they are normally more-precise instruments. Theodolites use micrometer microscopes that are especially designed for rapid and accurate readings and are used to read the graduated vertical (for elevation) and horizontal (for train) circles.

Micrometer microscopes create such precision that the accuracy of the optical reading device is governed by the circle and not by the way the circle is read. Different types of theodolites can be read directly to 10 inch, 1 inch, or 0.1 inch of arc. Figure 3-8 is an example of a typical theodolite.

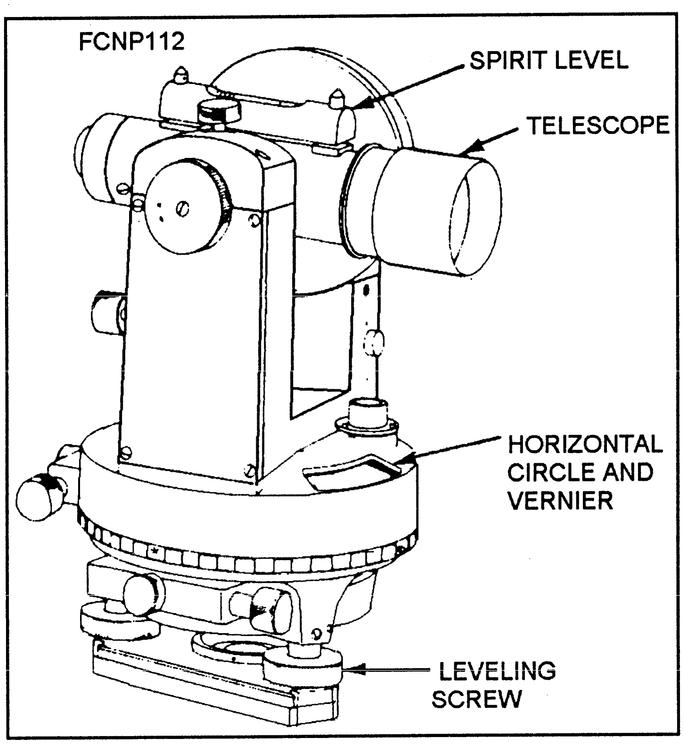

Figure 3-7.—Typical transit.

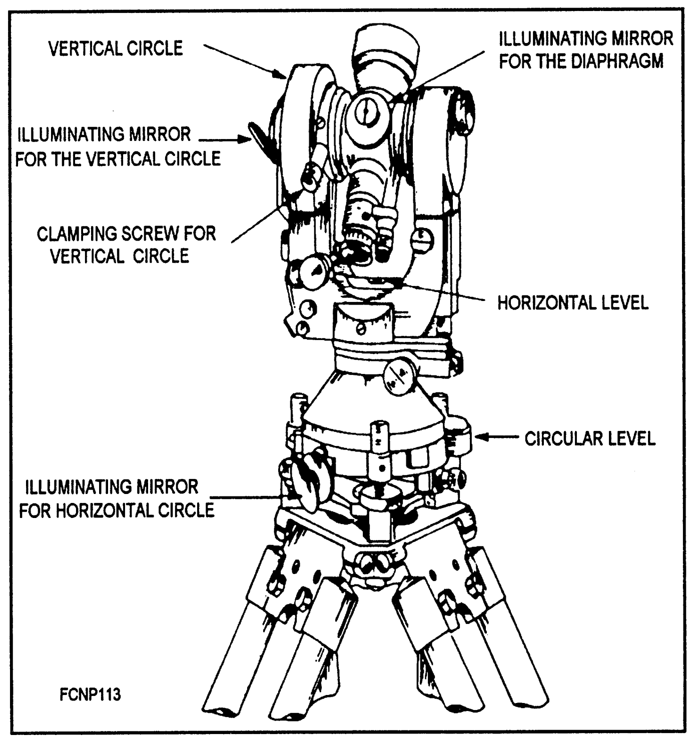

Figure 3-8.—Typical theodolite.

CLINOMETERS

Clinometers are used for measuring inclinations in the horizontal plane. They are used in naval shipyards principally to measure inclinations in equipment foundations and equipment roller-path inclinations (RPIs). All clinometers use a spirit level for indicating the true horizon and have some means of measuring inclinations of the base with respect to the horizon (spirit level).

Figure 3-9 shows the type of clinometer commonly used for making accurate RPI measurements. The micrometer drum 90° clinometer is read directly to 1 inch and can be interpolated to within 15 inches on the drum. The 6-inch-base length makes this type of clinometer suitable for many uses.

An adjustable base permits reading angles from zero, even when working surfaces are not perfectly horizontal.

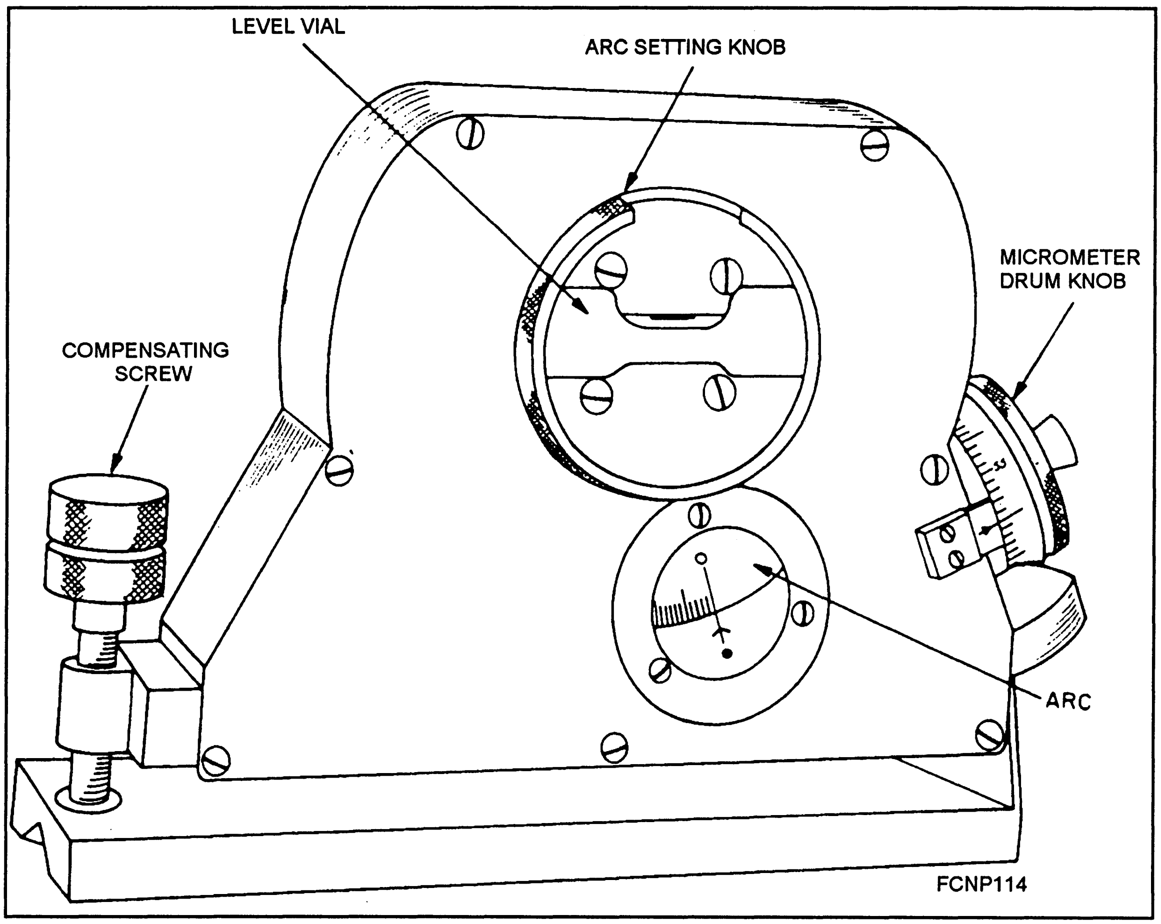

Figure 3-9.—Typical clinometer.

LEVELS

The two types of levels are (1) those that indicate entirely by means of graduations on the level vial, and (2) those adjustable types that are hinged at one end and have calibrated micrometer adjustments at the other end to extend the range beyond that on the level vial alone.

ALIGNMENT SIGHTS

Alignment sights are used to establish the pointing line of equipment. The pointing line maybe the bore axis of a gun, the centerline of a torpedo tube, the propagation axis of a radar beam, or some other similar line. Accurate alignment is not possible unless the pointing line is accurately determined. Some alignment sights are temporarily installed and are used for alignment and then removed from the equipment. Others are permanently installed and remain as part of the equipment.

Alignment sights include boresight telescopes and self-contained optics.

Boresight Telescopes

Boresight telescopes are used to represent the bore axis of a gun. These instruments are designed with self-contained optics in a single unit. The optics and features for positioning the instrument and securing it in the gun are all part of the unit. Most boresights of this class are provided with mounting surfaces that fit accurately into the gun bore. When the instrument is inserted into the gun bore, the LOS is brought into exact alignment with the gun-bore axis. Figure 3-10 shows atypical boresight with self-contained optics.

Self-Contained Optics

In alignments that use fixed, self-contained optics, the telescope is permanently mounted on a machined surface and accurately positioned so that the telescope LOS is parallel to the pointing axis of the antenna dish. Actual alignment is accomplished by mechanical movement of the antenna dish so that the radar beam is parallel to the telescope LOS or movement of the telescope so that it is parallel to the radar beam. Figure 3-11 shows typical fixed, self-contained alignment sights.

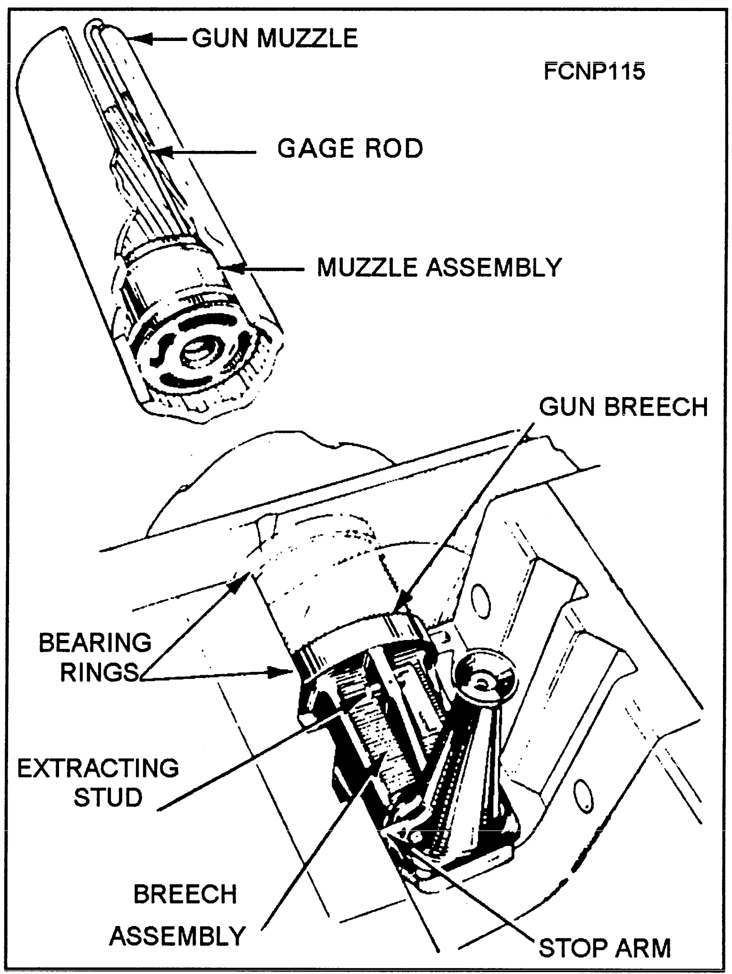

Figure 3-10.—Typical boresight with self-contained optics.

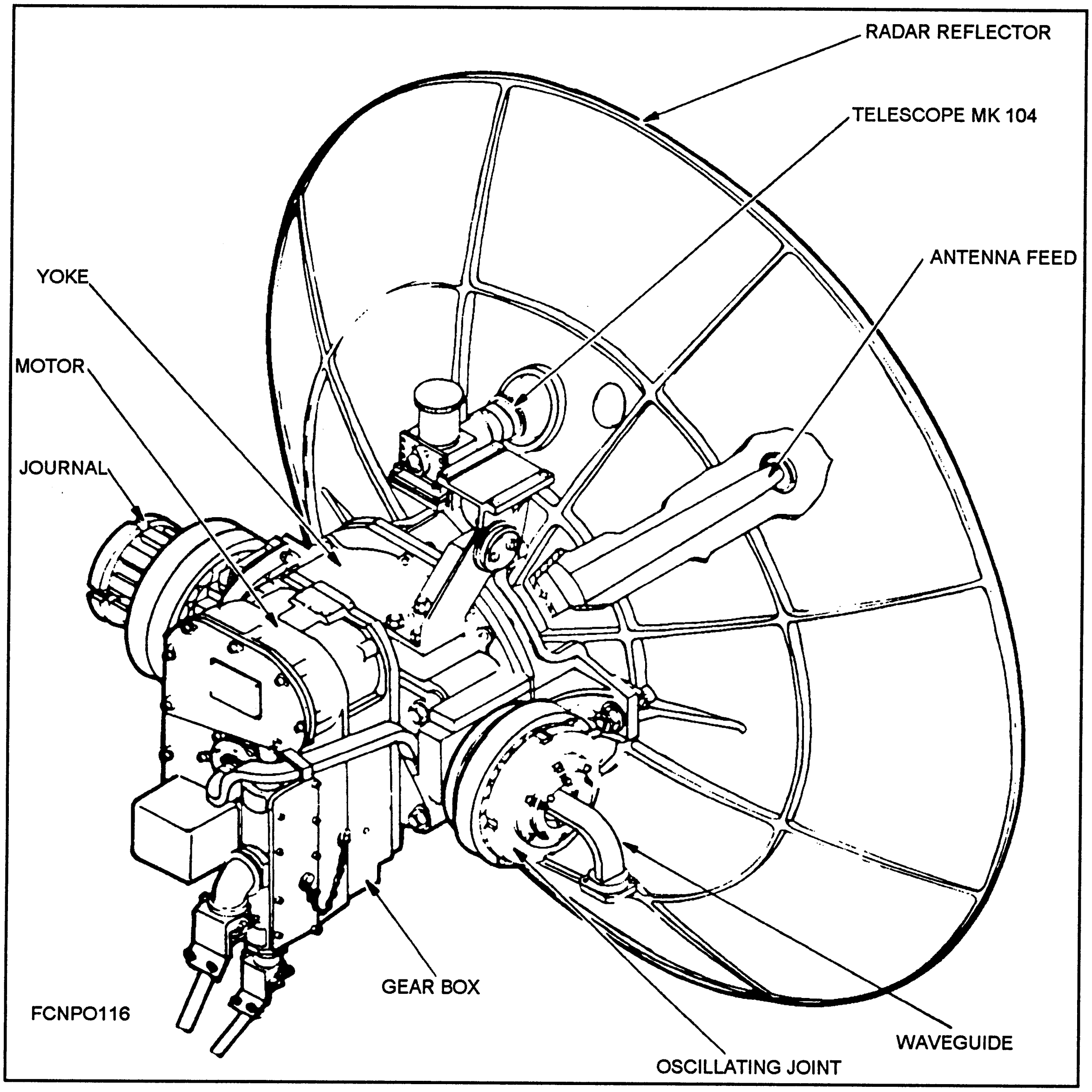

Figure 3-11.—Typical fixed, self-contained alignment sights.

TRAM BARS AND TRAM BLOCKS

Tram bars are used to set an element to an exact position, to determine the distance between two tram blocks that are fastened to the element. One block is fastened to the rotating structure of the element, and the other block is fastened to the fixed structure of the element. As shown in figure 3-12, the tram bar is used to ensure the correct positioning of the movable block.

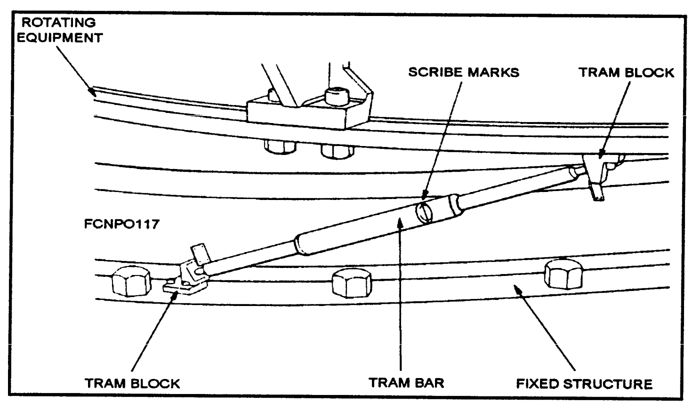

Figure 3-12.—Tram bar and tram blocks.

The two types of tram bars are rigid and telescopic. The rigid tram bar is of fixed length and does not allow for error. The telescoping feature of the telescopic tram bar makes it more convenient and safer to use. For this reason, this chapter discusses the telescopic tram bar. Both, however, accomplish the same purpose.

As shown in view A of figure 3-13, the telescoping tram bar consists of two parts, one bar sliding within the other. The parts of the bars have a small amount of movement with respect to each other and are extended by an internal spring. A scribe mark on the inner part is visible through an opening in the outer part. Engraved on the edges of the opening is a graduated scale that runs on each side of a zero mark. When the inner scribe mark and the outer zero mark are in line, the tram bar is at the correct length.

As shown in view B of figure 3-13, a gage is furnished with the instrument to check that the zero line and the scribe mark match when the length is correct.

As shown in view C of figure 3-13, the block has pins with cupped ends that fit the rounded ends of the bar. One block has a fixed pin, whereas the other has a movable pin. After the blocks are welded in place on the element, the movable pin can be adjusted so that the scribe mark and the tram bar zero line match exactly when the dials of the element are at some predetermined reading. The movable pin is then tack-welded in place. To protect the ends of the pins from damage and corrosion when the pins are not in use, the pin ends are covered with grease-filled caps.

Tramming operations should be performed with great care to prevent injury to personnel or damage to the equipment.

- The equipment power drives should not be used unless it is absolutely necessary.

- The equipment should be positioned to the approximate tram position and the bar inserted with the heavier end down.

- The bar should not be held in place while the tram blocks are moving with respect to each other. However, if necessary, holding should be done only while the blocks are moving away from each other.

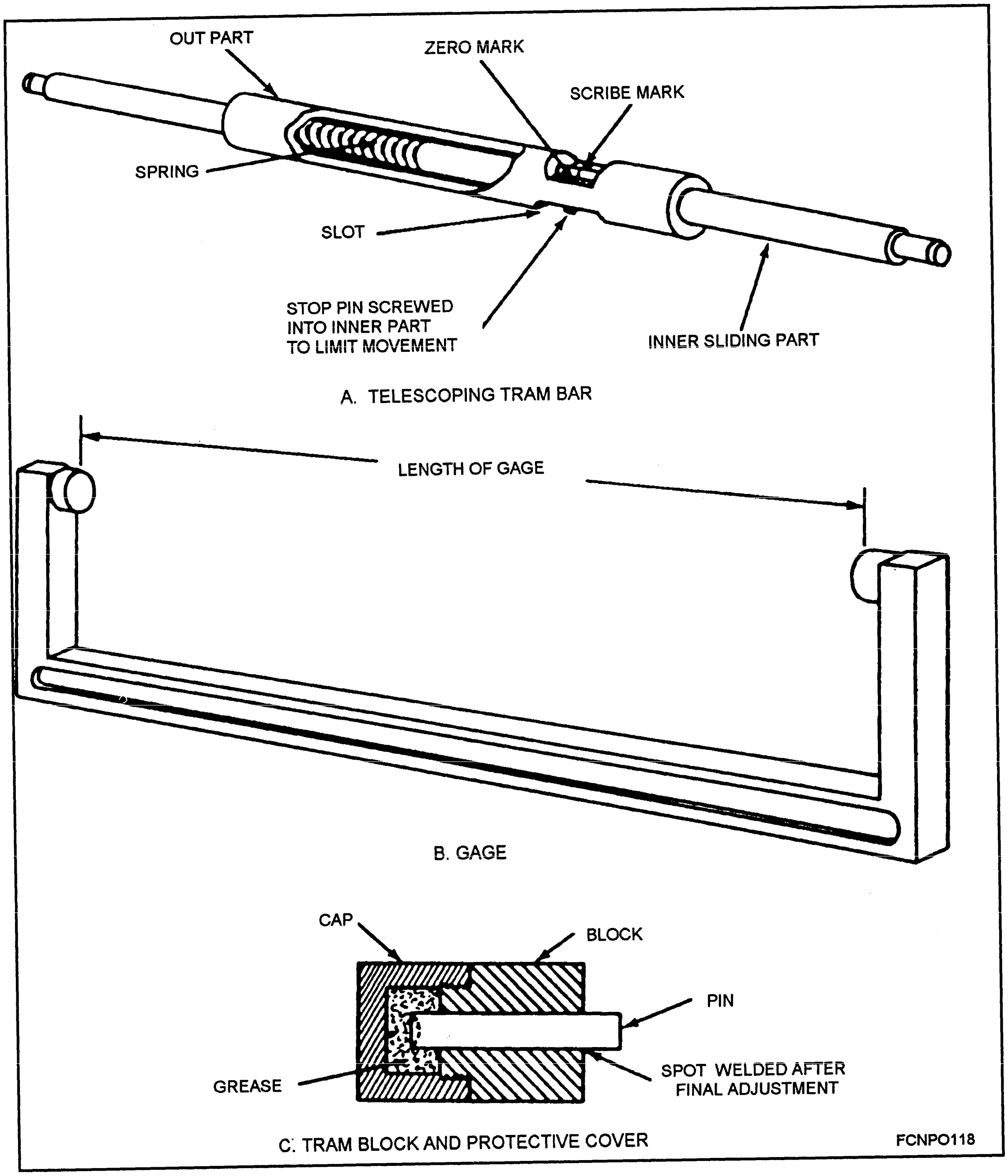

Figure3-13.—Telescoping tram bar and related equipment.

BENCHMARKS

Benchmarks are small metal plates that contain an engraved cross. The plates are either brazed or welded to some rigid portion of the ship's structure at a position where the engraved cross can be sighted on with the reference element (director). A benchmark maybe engraved on a flat plate for bulkhead mounting or on a block with an inclined surface so that the mark is clearly visible on the ship's deck. Benchmarks are reference marks used in alignment to establish the angular relationships (elevation and train) of an element's line of sight to the ship's structure. When an element is sighted at its benchmark, its dial readings should agree with recorded values. If there is disagreement, alignment of the element is necessary.

Figure 3-14 shows two typical benchmarks.

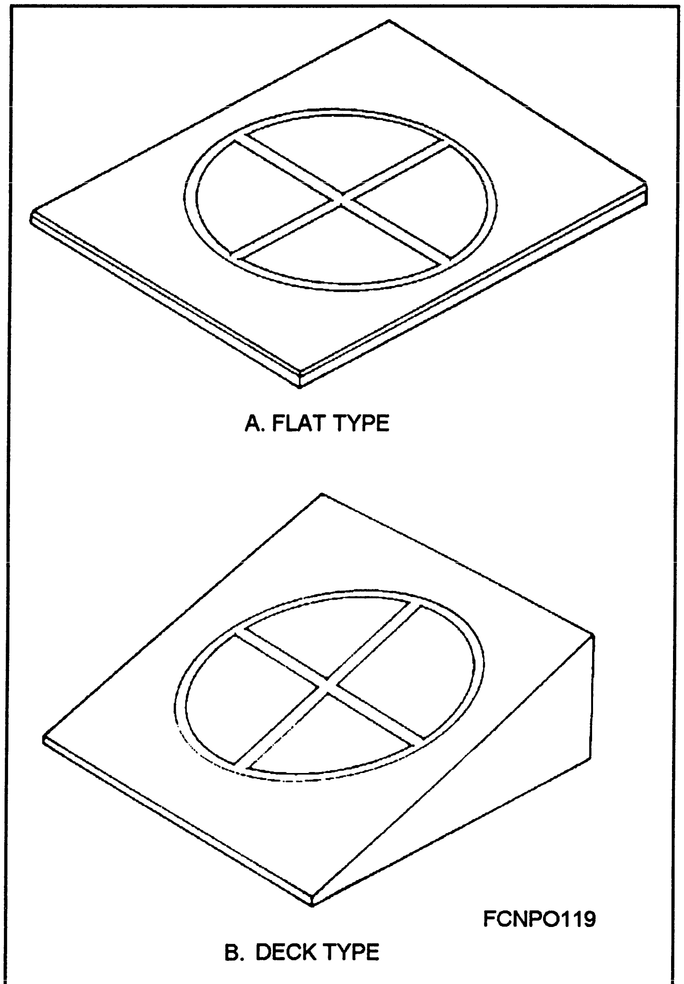

Figure 3-14.—Typical benchmarks.

DIALS

Although the dials that must be read by alignment personnel are part of the equipment being aligned and cannot properly be considered to be equipment requiring alignment, a brief review is given of the precautions to be observed in reading dials.

The correct reading of dials is extremely important in alignment work. A simple mistake. in reading a dial can cause great difficulty or unnecessary work. Such mistakes are often made, even by experienced personnel, and are made most often because of carelessness or undue haste.

Before you attempt to read a dial, it is essential that you familiarize yourself with the values of the graduations and the manner in which the dials operate. This is particularly important if the dials are not read frequently. In such cases, several trial readings should be taken and checked with someone else before starting the alignment. Even familiar dials should be read systematically and deliberately. Above all, no attempt should be made to hurry. A few extra seconds spent in making a careful reading may later save hours of work involved in performing an unnecessary adjustment procedure.

ALIGNMENT CONSIDERATIONS

There are certain major steps in combat systems alignment that must proceed according to a specified sequence. Strict adherence to the order in which the steps are conducted is essential to the successful completion of the alignment task. The sequence in which these steps are to be performed is shown in table 3-1.

Table 3-1.—Procedures for Combat Systems Alignment

STEP	PROCEDURE
1	Establish reference planes.
2	Place reference marks.
3	Establish parallelism.
4	Perform fire-control radar RF optical alignment.
5	Establish train and elevation zero alignment.
6	Perform train and elevation space alignment (star checks).
7	Establish initial benchmark and tram reference readings.

Initially, these steps are accomplished by the installing activity during ship construction. Thereafter, shipboard alignment checks and verification consist mainly of benchmark checks, tram checks, and star checks.

This section briefly discusses the establishment of reference planes, the placement of reference marks, the establishment of parallelism, the performance of fire-control radar radio-frequency-optical alignment, the establishment of training and elevation zero alignment, the performance of training and elevation space alignment, the establishment of benchmark and tram reference readings, and the combat/weapons systems smooth log.

ESTABLISHMENT OF REFERENCE PLANES

The first major alignment step accomplished by a support activity is the establishment of reference planes. Referencing surfaces consist of the ship base plane (SBP), master reference plane (MRP), centerline reference plane (CRP), and weapons-control reference plane (WCRP).

Ship Base Plane

The ship base plane (SBP) is the basic horizontal plane of origin. The SBP is perpendicular to the ship's centerline plane and includes the base line of the ship, but it is not necessarily parallel to the keel of the ship. The SBP is used in establishing the MRP.

Master Reference Plane

The master reference plane (MRP) is the first physical plane that is established for combat systems alignment. The MRP is parallel to the SBP and is represented by a master level block or plate, usually located on a lower deck of the ship. The plate is installed, aligned, and leveled only once after hull integration and is never adjusted thereafter. The master level plate serves as the reference for machining the foundations of the combat systems equipment throughout the life of the ship.

Centerline Reference Plane

The centerline reference plane (CRP) is established during ship construction by the installation activity. It is the plane containing the ship's centerline and is perpendicular to the MRP. The CRP is the reference used to establish train zero alignment of all combat systems equipment. The CRP is used throughout the life of the ship.

Weapons-Control Reference Plane

The weapons-control reference plane (WCRP) is the plane to which the foundations and the roller-path planes (RPPs) of all combat systems equipment are leveled. The WCRP is used throughout the life of the ship to determine RPP parallelism between the equipment of the combat/weapons systems.

PLACEMENT OF REFERENCE MARKS

The second major alignment step is the placement of centerline marks, offset centerline marks, and equipment benchmarks, which are performed by a shipyard or support activity.

Centerline Marks

Centerline marks are established during initial construction to represent the ship's centerline. Small plates (at least three forward and three aft) are installed at intervals along the centerline to mark its location. Small plates are also installed in certain ship spaces to mark the location of the centerline.

Offset Centerline Marks

Offset centerline marks are also established during initial construction to facilitate combat systems alignment. The offset centerline is normally established parallel to or perpendicular to the ship's centerline. Offset centerline marks not parallel or perpendicular to the ship's centerline are stamped or marked with the angles relative to the ship's centerline. Offset centerline marks are also established, as required, in interior compartments of the ship to facilitate the alignment of the combat systems. Both the centerline and offset centerline marks are installed to preclude the necessity for repeating the centerline surveying during subsequent alignment.

Equipment Benchmarks

Each equipment with an alignment telescope has a benchmark that can be sighted through the telescope. Equipment benchmarks are installed at any convenient location that is visible through the equipment telescope. These benchmarks are used throughout the life of the ship to verify that the alignment is still within tolerance.

ESTABLISHMENT OF PARALLELISM

The third major alignment step is the establishment of parallelism between the RPPs of all equipment in the combat system. The degree of parallelism required is based on the design and manufacturing criteria, the operational environment, and the requirements of the various operational modes. The steps necessary to achieve the degree of parallelism required are inclination verification, foundation machining, and interequipment leveling.

Inclination Verification

Inclination verification consists of measurements of the tilt between two RPPs. The amount by which one RPP is tilted with respect to another RPP is expressed as the *angle of inclination* between the planes and the bearing where this inclination occurs. The tilt of the RPP is usually determined by the two-clinometer method or the horizon-check method.

Foundation Machining

Foundation machining pertains to the physical processes required to attain a specified degree of parallelism and is performed by a support activity. Physical processes may involve using milling machines or welding premachined surfaces in place. Machining is accomplished with the ship afloat and loaded to simulate the fill-load-deflection curve and the strains of major concentrated loads. The ship is kept in the specified loaded condition for a sufficient period of time (48 hours) before the start of machining operations to allow ship structural members to adjust to the load. Strict adherence to normal shipyard techniques of machining during periods of minimum temperature changes is observed.

Interequipment Leveling

Interequipment leveling is achieved by leveling rings, shims, adjusting screws, or software compensation. Leveling capabilities are used to achieve the RPI tolerances imposed by the minimum acceptable requirements or the various operational modes of the combat system. Where leveling capabilities are not provided, RPI tolerances are achieved through foundation machining. In cases where foundation machining is initially used to meet these tolerances, RPI compensation through computer software changes may be introduced, if necessary.

PERFORMANCE OF FIRE-CONTROL RADAR RADIO-FREQUENCY OPTICAL ALIGNMENT

The fourth major alignment step is the verification of fire-control radar radio-frequency (RF) optical alignment (collimation). During initial installation, the RF optical alignment is established and the optics are secured in place. During subsequent alignment checks, the radar antennas or the optics, as applicable, are adjusted to correct any alignment error between the optical axis and the RF axis. When the radar is tracking, the RF axis is the reference used for target location. RF optical alignment is an equipment-level test and is performed on a certified shore tower facility or, in the case of some radars, may be performed while tracking a target.

ESTABLISHMENT OF TRAIN AND ELEVATION ZERO ALIGNMENT

The fifth major alignment step is the train and elevation zero alignment. This alignment, performed by the ship's force or a support activity, is conducted to ensure that all combat systems equipment points to the same point in space when so directed.

The two types of train and elevation zero alignment are equipment with alignment or boresight telescopes and equipment without telescopes.

- **Equipment with alignment or boresight telescopes:** Train zero is defined as the angle at which the telescope axis is parallel to the ship's centerline plane. Elevation zero is that angle at which the telescope axis is parallel to the RPP. Train and elevation zero alignment is carried out by physically positioning each equipment to train and elevation zero by using surveying techniques and zeroing the dials and synchros, or by compensating for the train and elevation errors through computer software changes.'

- **Equipment without telescopes:** Train and elevation zero alignment is accomplished by matching an indicator to a scribe mark or plate and zeroing the dials and synchros.

PERFORMANCE OF TRAIN AND ELEVATION SPACE ALIGNMENT (STAR CHECKS)

The sixth major step of initial alignment is train and elevation alignment between the alignment reference and other combat systems equipment. This is accomplished by comparing equipment position when the optical axes are made parallel by sighting on a celestial body. If the train and elevation readouts for the equipment do not agree within the operational tolerances previously established for that equipment, alignment is necessary. After corrective alignment is accomplished, a new set of tram or benchmark readings must be taken and recorded. This alignment check can be performed by a ship's force or a support activity.

ESTABLISHMENT OF BENCHMARK AND TRAM REFERENCE READINGS

The seventh and last major alignment step is the establishment of reference readings that are performed by a support activity or a ship's force. Reference readings are established to furnish an easy means of checking train and elevation alignment in the future. This is necessary because the dials or synchros may become misaligned as a result of vibration and normal wear or equipment disassembly for the replacement of worn parts.

Tram and benchmarks are provided to facilitate checking combat systems equipment at a definite train and elevation position. The position selected may be any convenient value within the limits of the equipment movement. The dial readings for these positions are recorded on the sheets provided in the alignment smooth log. If the equipment remains aligned correctly for zero train and elevation, the recorded dial readings are the same whenever the equipment is moved to the tram or benchmark position.

The alignment verification obtained by using a benchmark is accurate only if the angle between the reference line and the position of the pointing line established by the benchmark does not change as a result of hull distortion or some other cause. Adjustments to equipment should not be made by using the result of a single benchmark check. Instead, benchmark results should be recorded each time they are performed so that a determination can be made when a benchmark error begins repeating itself and becomes an indication that further alignment checks are required.

Tram bars and tram blocks may also be used to establish an angle by determining a definite distance between a point on the rotating structure of the equipment and a point on its fixed structure. An error, as defined by tram readings, may also result if the fixed structure shifts on its mounting. Any adjustments to equipment, like benchmarks, should not be made on the basis of a single tram check.

Some equipments have both benchmarks and trams. When the benchmark reading changes and the tram reading remains unchanged, the extent of hull distortion is revealed.

COMBAT/WEAPONS SYSTEMS SMOOTH LOG

The combat/weapons systems smooth log is similar to the former battery smooth log. and fire-control smooth log, among others. Thus, the combat/weapons systems smooth log is the title that maybe applied to all smooth logs that are required to be kept.

Most often, the combat/weapons systems log contains sections devoted to alignment, erosion, rounds fired, radar, and exercises and rounds fired.

- **Alignment:** Includes summaries of alignment data for fire-control systems, train checks, benchmarks established and recorded, roller-path compensator settings, horizon checks, radar antenna alignment records, etc.

- **Erosion:** Includes star gage data, erosion gage data, equivalent service rounds (ESRs), pseudo-equivalent service rounds (PESRs), and records of bore searchings.

- **Rounds Fired:** Includes entries in tabular form for gun barrels by serial numbers, which show rounds fired, types of projectiles, powder charges, powder indexes, and ESRs.

- **Radar:** Includes dates and results of radar adjustments, collimations, calibrations, double-echo checks, and any corrective measures taken, such as the negative range zero set from the results of the double-echo check.

- **Exercises and Rounds Fired:** Includes dates and types of exercises or action firings, overall results, complete summaries for unsatisfactory firings, corrective measures taken, and listing of the arbitrary corrections to hit (ACTH) or any other initial spots that were used.

Alignment data must be documented on completion to provide information for future checks and to inform responsible personnel of equipment and subsystem alignment status. A complete and accurate alignment data package is essential for effective combat systems alignment.

RECOMMENDED READING LIST

NOTE: Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. Therefore, you need to ensure that you are studying the latest revision.

Combat System Alignment Manual for CG-47 Class, NAVSEA SW225-BN-CSA-010, Naval Sea Systems Command, Washington, DC, 1993.

Combat System Alignment Manual for DDG-51 Class; Alignment Verification and Corrective Alignment Procedures, NAVSEA SW225-CH-CSA-010, Naval Sea Systems Command, Washington, DC, 1993.

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